

## THE PANAMA CANAL.

IN the issue of August 24 a review was given of General Abbot's book on "Problems of the Panama Canal," published this year; and in this book the construction of a canal with locks across the



Photograph by W. P. Tisdell.

FIG. 1.—The Culebra Cut, Panama Canal, looking North.

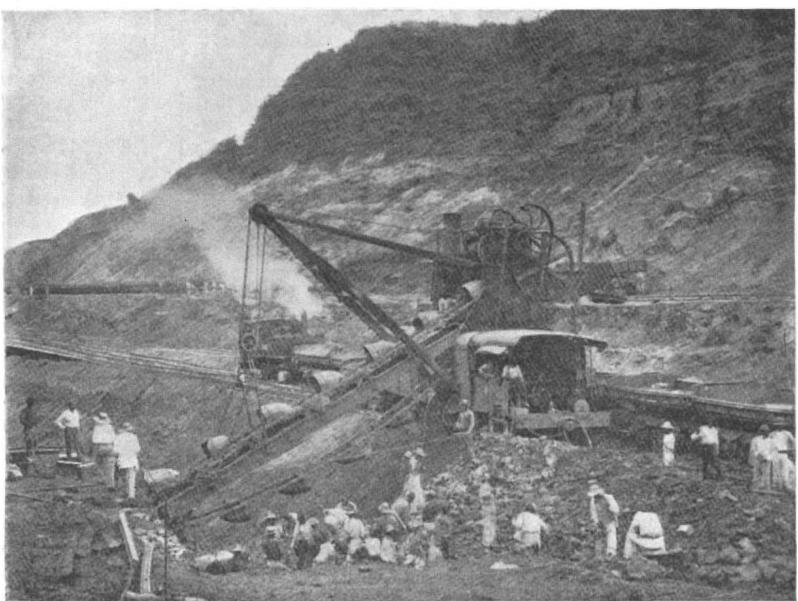
Isthmus of Panama, in preference to a sea-level canal, was strongly insisted upon. The October number, however, of the *National Geographic Magazine*, published in Washington, contains an article on "The Panama Canal," by Rear-Admiral Colby M. Chester, U.S.N., in which the advantages of a sea-level canal are quite as urgently advocated. Accordingly, the only points which have hitherto been definitely settled by the United States Government assuming the responsibility for the construction of the canal, are the final selection of the Panama route for the inter-oceanic canal and the consequent abandonment of the rival Nicaragua scheme, and the certainty of adequate funds being available for the completion of the Panama Canal, the want of capital having proved the most serious obstacle to the progress of the works when under the control of a private French company.

There are undoubtedly several difficulties connected with this enterprise which have still to be overcome, such as scarcity of labour and unsanitary conditions in a proverbially unhealthy tropical climate; the vast amount of excavation that has to be accomplished in cutting through the high central ridge constituting the divide between the Atlantic and Pacific watersheds (Fig. 1), composed in the higher portions of treacherous strata exposed to an exceptionally heavy rainfall; and the control of the great torrential floods

of the river Chagres cutting in several places across the line adopted for the canal, which follows the valley of the river along the Atlantic slope. These impediments, however, in course of time, by the help of ample funds, the progress of sanitary science, the great improvements effected in excavating and dredging plant (Fig. 2), and the increased experience gained in the construction of reservoir dams, should not prove insurmountable. In reality, the question which at the present time demands a definite and early decision is whether the canal is to be constructed with a summit-level a considerable height above sea-level, to be reached by means of locks on each slope, or is to be excavated down to a sufficient depth to form a sea-level canal with only a regulating lock,  $4\frac{1}{2}$  miles from the Pacific coast to Panama, to prevent the tidal rise in the Pacific Ocean of  $21\frac{1}{2}$  feet at springs creating injurious currents into and out of the canal.

When the Panama Canal scheme was started at Paris in 1879, M. de Lesseps insisted that it should be constructed at sea-level, like the Suez Canal; and the works were commenced in 1881 on that basis, relying upon the eventual success of the earlier work, without adequate preliminary investigations, and without due consideration of the differences in the conditions of

the two sites. In 1887 the unexpectedly large cost and slow progress of the works led the canal company to diminish considerably the amount of excavation by the introduction of locks, thereby effect-



Photograph by W. P. Tisdell.

FIG. 2.—A Steam Shovel at work in the Culebra Cut, Panama Canal.

ing a large reduction in the ultimate expenditure, and in the time required for the completion of the canal, as can be readily appreciated by a reference to the longitudinal section of the canal with locks (Fig. 3).

This is the principle upon which work on the canal since that time has been conducted, with modifications from time to time in the proposed summit-level; it was followed, after the failure of the old company in 1888, by the new company constituted in 1894, so far as their limited funds permitted; it was approved by the various French Commissions which reported on the canal; and it was adopted by the International Isthmian Canal Commission of 1899-1901, which submitted to Congress the design shown by the accompanying longitudinal section and plan. This design consists of a summit-level  $21\frac{1}{2}$  miles long, with its water-level 82 to 90 feet above mean sea-level, reached from the sea-level portion of the canal on the Atlantic side, 16 4-5 miles long, by two adjoining locks at Bohio, and from the sea-level section on the Pacific side, about  $8\frac{1}{2}$  miles long, by a lock at Miraflores arresting the tide and raising the water-level of the

construction of the Panama Canal," in which a sea-level canal is recommended, thereby abandoning the proposals of all the engineers who had previously studied the question since 1888, and reverting to the original scheme of M. de Lesseps. This project consists of a canal with a bottom-width of 150 feet, a minimum depth of water of 35 feet, and twin tidal locks at Miraflores having an available length of 1000 feet and a width of 100 feet; and it is estimated that this canal could be completed in ten or twelve years at a cost of 230,500,000 dollars, the Chagres River being controlled by a dam at Gamboa, forming a lake from which the surplus waters would be discharged by a tunnel through the dividing ridge into another river-basin. The committee further urges that if a canal with locks should nevertheless be preferred, its summit-level should in no circumstances have its

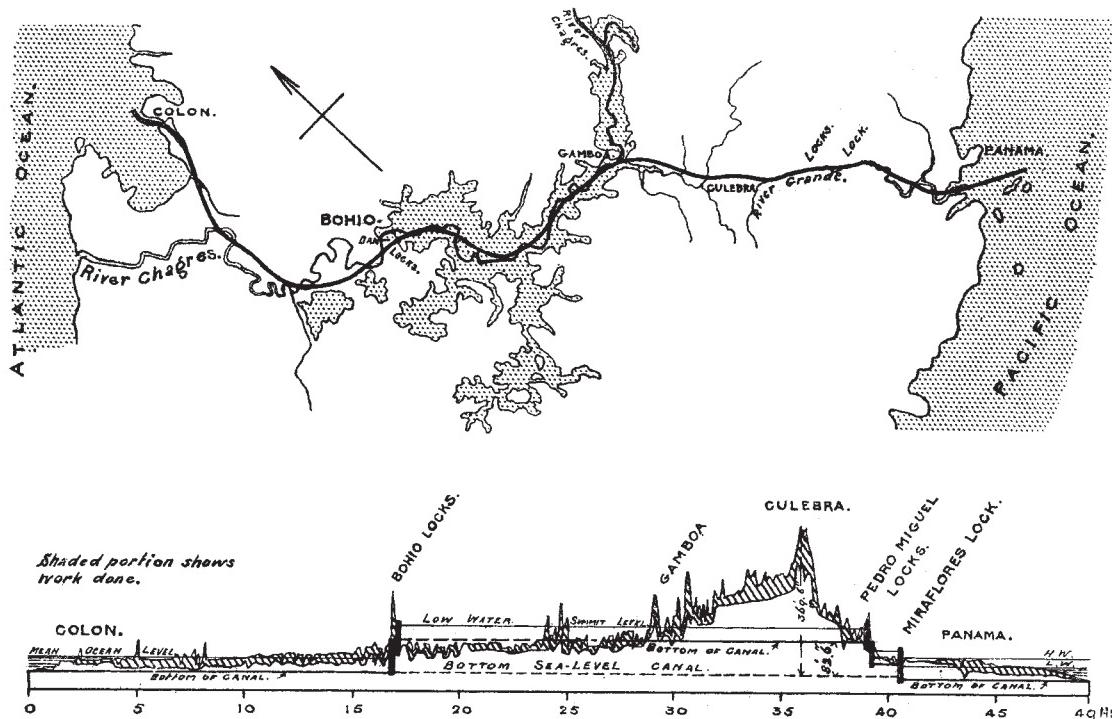


FIG. 3.—Panama Canal. Scheme with Locks. Commission of 1899-1901. Plan, Scale 1/600,000. Longitudinal Section, Horizontal Scale 1/600,000, Vertical Scale 1/6,000.

canal 30 feet above mean sea-level in a reach only  $1\frac{1}{2}$  miles long, and two adjoining locks at the end of this reach connecting it with the summit-level (Fig. 3). For thirteen miles of the summit-level on the Atlantic side of the deep Culebra cutting, the canal would pass through a lake formed in the Chagres valley by a dam near Bohio, as shown on the plan, which would materially accelerate navigation along this part. In an article on "Progress of the Panama Canal," following the one by Admiral Chester, to which the plan and section here reproduced are appended, it is stated that this design with locks is the only one "on which the Canal Commission has as yet any authority to spend money."

The canal problem entered upon a new phase this year by the presentation last February of a report to the United States Isthmian Canal Commission by its Engineering Committee, which Admiral Chester terms "the first definite engineering plans for the

water-level more than 60 feet above mean sea-level, and estimates that such a canal would cost 178,013,406 dollars, and a canal with only a 30-feet summit-level 194,213,406 dollars. The committee considered that a sea-level canal, which is free from the restriction imposed by locks on the volume of traffic and size of ships passing through them, and could easily be enlarged and deepened to accommodate an increased traffic and larger vessels, would be well worth the additional cost, and that in view of the great progress achieved in the rate of excavation, the period required for its construction would be moderate; and the opinion was expressed that though a canal with locks could be made which might subsequently be transformed into a sea-level canal, such a modification could only be effected at great inconvenience to navigation, and at an excessive cost. A scheme proposed by Mr. Bunau-Varilla with this latter object in view is described in the article on "Progress of

the Panama Canal," in which four locks on each slope would lead to a summit-level 130 feet above sea-level; and so by greatly reducing the excavation required in the Culebra cutting, the designer considers that the canal could be completed in four and a half years; and it is proposed that a very wide earthen dam should be formed at Bohio with materials dredged in excavating the canal, and conveyed through pipes to the site, thereby creating Lake Bohio, as shown on the plan. Another lake would be formed by a dam at Gamboa, outside the line of the canal; and this canal with locks is to be transformed into a sea-level canal, when required, entirely by dredging without impeding navigation, the dredgers being worked electrically by means of the water-power from the lake, the basin of which is to serve as a depositing ground for the dredged materials.

Admiral Chester, as an old naval officer, is naturally in favour of a sea-level canal, and supports his view by numerous extracts from the report of the Engineering Committee; whereas General Abbot, with his wide hydraulic experience, and the International Isthmian Canal Commission of 1899-1901 have advocated the construction of a canal with locks. In face of this conflict of opinion, it is natural that the United States Government referred the technical question last summer to an International Engineering Advisory Board, which recently visited the site; but, according to some newspaper correspondents, the members of this commission returned to Washington with discouraging and discordant views, so that their approaching report to the President will be awaited with much interest.

Undoubtedly, the conditions affecting the choice between a canal with locks and a sea-level canal have been modified by the United States Government having undertaken the construction of the canal, for the capital cost, which is a most important question for a private company, is of much less consequence to a Government, provided very material advantages, either as to facilities of navigation or a diminution in the expenses of maintenance, can be secured by a larger initial outlay; and, within certain limits, a prolongation of the period of construction is also of less vital importance. Too much stress, however, appears to have been laid in the report of the Engineering Committee of this year on the restriction offered by locks to navigation and increase in the size of ships, and too little account taken of the cost of enlarging a canal through an exceptionally deep cutting; and also probably much too sanguine a view is entertained of the period required for the large additional quantity of excavation necessitated by a sea-level canal, especially considering the uncertainties as to the supply of labour.

The only restrictions to navigation caused by a canal with locks are the time occupied in passing through them, and the possibility of vessels being built larger than they could accommodate; but the loss of time can be considerably reduced by suitable arrangements for filling and emptying the locks, their capacity for traffic can be readily increased by duplicating them when required, and their dimensions would naturally be made at the outset, like the tidal locks at Miraflores, adequate for any probable increase in the size of the vessels. Moreover, in the design shown on the plan, a great portion, if not the whole, of the time expended in locking would be recouped by the increased speed attained by vessels in traversing the thirteen miles of lake navigation. The advantage of facility of enlargement claimed for a sea-level canal really more rightly belongs to a canal with locks, provided the locks are constructed with due foresight of future requirements; for whereas the portions of the canal from the Atlantic to Bohio, and

from the Pacific to Miraflores, with a total length of  $25\frac{1}{2}$  miles, are the same in both schemes, owing to the excavation already accomplished, as shown by shading on the longitudinal section, about 11 miles of the lake portion in the canal with locks are considerably lower than required for giving 35 feet draught of water; whilst the remaining  $10\frac{1}{2}$  miles of the summit-level of the canal with locks could be enlarged and deepened by 82 feet less depth of excavation throughout than would be necessary for the sea-level canal (Fig. 3).

The only serious objection that has been raised against the design shown in the illustrations is that the proposed dam near Bohio would have to be carried down 42 feet lower to reach a foundation of rock than was anticipated; but it seems almost incredible that the commissions appointed during the period that the New Panama Company had control of the works, the special mission of which it was to determine the feasibility and best means of completing the canal, should have neglected such an important investigation as the foundations for the Bohio dam. The statements that the Engineering Committee, in its report of this year, had presented the first definite plan for the construction of the canal, and that the American engineers had discovered a better site for a dam at Gamboa, which formed part of the original scheme, seem to indicate a bias against previous schemes, and a desire to appear to strike out a novel line. So far as information is at present available, and assuming that the Bohio dam can be executed as designed, it appears that a canal with locks would cost much less, be much sooner completed, and would be much more easily and cheaply enlarged than a sea-level canal, and that the greater facilities for navigation which might possibly be afforded by the larger scheme would, owing to the lake navigation offered by the other, be so insignificant as not to justify the additional cost, delays, and uncertainties the construction of a sea-level canal would entail.

Since the above article was written, the Advisory Board of Engineers has by a majority of three recommended the construction of a sea-level canal, three Americans and five foreigners voting in favour of it, and five Americans against, giving the preference to a canal with locks; but the report of the Board has not yet been published.

#### THE BIOMETRICS OF BRAIN-WEIGHTS.

"We are not endeavouring to discredit anthropology, but to furnish such branches of it as anthropometry and craniology with new tools—a little sharp-edged to the uninitiated who handle them inadvertently—but which will raise anthropometry and craniology in the future into the category of the more exact sciences" (Karl Pearson, *Biometrika*, vol. iii., p. 153, 1904).

"There is a mathematical science of statistics which must be learnt, and papers dealing numerically with anthropometric and craniometric data which do not now apply this theory are simply outside the field of science" (*Biometrika*, vol. iii., p. 397, 1904).

**I**T is not a raid, but a victorious invasion, that Prof. Karl Pearson and his school have made into the realms of anthropology, with the result that all that part of it which deals with men in the mass becomes an annex of the mathematician. The invasion occurred at a most opportune time; great collections of data which had been accumulated by the anthropologist threatened to bury him, for he had neither the method nor the appliances for welding them into a composite whole. Especially was this the case with the endless measurements of brain-weights obtained most laboriously by the anatomist and pathologist; they urgently required an application of the "mathematical science of statistics." Hence the series of articles which occupy the greater part of a number of